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28 July 1966

Office of Grants and Research
Contracts
National Aeronautics and Space Administration
Washington, D.C. 20546

Attn: Code SC
Subj: Semi-Annual Report covering period
1 January 1966- 31 July 1966
Grant No. NSG-448
Ohio State University Research Foundation
Antenna Laboratory, Project 1691

I. Introduction

Research has been conducted in three general areas during this program interval. These are

1) the aperture admittance of a rectangular waveguide radiating into a homogeneous slab

2) the effect of inhomogeneous media on the aperture admittance of small aperture antennas, and

3) development of geometrical techniques for the analysis of diffraction problems. The following reports have been published:

L.L. Tsai, R.C. Rudduck, "Accuracy of Approximate Formulations For Near-Field Wedge Diffraction Of A Line Source", 1691-18, 15 March, 1966, Antenna Laboratory, The Ohio State University Research Foundation, prepared under Grant No. NSG-448 with National Aeronautics and Space Administration.

S. Gotkis, "The Substitution Of A Semi-Infinite Homogeneous Dielectric Medium For A Plasma Slab", 1691-19, 30 April 1966, Antenna Laboratory, The Ohio State University Research Foundation, prepared under Grant No. NSG-448 with National Aeronautics and Space Administration.

II. Work Accomplished

The analysis of the admittance of a rectangular waveguide aperture covered by a dielectric slab was essentially completed during this program interval. The results obtained from the computer program for this analysis were checked in several ways. In one check the guide aperture admittance for sufficiently thick slabs was found to converge to that of the guide radiating into a semi-infinite medium. In another check the aperture admittance for slab-covered rectangular apertures was compared with the plane-wave reflection from identical slabs. It was observed that for sufficiently thin slabs and low angles of incidence of the waveguide mode, the guide admittance would likely be in close agreement with the plane-wave reflection. This indeed was found to be the case, giving another indication of the validity of the results. Comparison of measurements made by National Aeronautics and Space Administration engineers at Langley Field showed generally good agreement with the slab calculations.

The TEM sectoral horn which was designed to measure the free space reflection coefficients of parallel-plate waveguide apertures was tested and found to give accurate results for the case in which an exact Wiener-Hopf analysis is available. Measurements obtained from the horn were then used to verify calculations by the wedge diffraction method for which no other analysis is available. Computations of the free-space reflection coefficient of the parallel-plate guide were completed and a report on the analysis and results is in process.

In the study of effects of inhomogeneous media on aperture admittance of antennas, a report was written on reflection by layered dielectric media in which the equivalent medium approach was examined. In a continuation of this study, results for the reflection coefficients of parallel-plate waveguides in the presence of layered dielectric media are being calculated. As a verification of the calculations, measurements are planned with the sectoral horn designed to measure free-space reflection coefficients of parallel-plate guides. Various media consisting of multilayer slabs will be used as a function of spacing from the sectoral horn aperture.

Research was continued on the diffraction of a non-uniform wave incident on a conducting wedge. Specifically, the non-uniform wave considered is that of a dipole pattern with the null of the pattern aligned with the edge of the conducting wedge. Two forms of the solution have been derived from the diffraction by a uniform wave; one form is obtained from the exact series solution of eigen function, the other from the dominant Fresnel Integral term of the asymptotic series. The two forms have been compared and the regions for which each form is useful were determined.

The diffraction of a non-uniform wave has been applied to the analysis of third order diffraction in the normally truncated parallel-plate guide. The use of only uniform wave diffraction is not satisfactory in this case because the amplitude variation of the illuminating second order wave must be taken into account. Calculations of the radiation pattern have been made in which the third order diffraction was analyzed by use of non-uniform wave diffraction. It was found that the third order diffraction significantly influences the pattern in regions near the plane of the guide aperture for guide widths less than a wavelength. These wedge diffraction computations using third order diffraction were compared with computations made by the Kirchoff aperture integration method. Significant difference between the two methods occurs in the region near the plane of the guide aperture, precisely where the third order diffraction is significant. Pattern measurements have been made which indicate that the wedge diffraction computations are more accurate; and, consequently, the third order diffraction as computed by non-uniform wave diffraction is verified.

III. Future Program

The investigation of problems concerning the admittance of aperture antennas radiating into dielectric or plasma media should be continued. This effort would be primarily concerned with open-ended waveguide apertures radiating into homogeneous dielectric slabs or inhomogeneous plasmas.

The impedance of the rectangular waveguide aperture covered by a homogeneous dielectric slab has been analyzed in terms of the plane wave spectrum of the rectangular aperture.

Thus, a slight modification of this analysis permits the computation of the impedance for other types of apertures radiating into a homogeneous slab. The only requirement for this modification is the determination of the approximate plane wave spectrum. In the case of exclusive dominant mode propagation the variational assumption that the spectrum is that of the dominant mode is usually good. Thus it is proposed to compute the admittance of other types of aperture antennas radiating into a homogeneous slab by modifying the available computer program. The effect of higher order modes will also be studied, e. g., the TE_{03} mode gives a significant contribution to the dominant TE_{01} mode impedance for a rectangular waveguide with a quartz plug.

The Equivalent Medium Concept is being applied to the impedance of a parallel-plate waveguide radiating into inhomogeneous plasma media. This work will be completed during next year's program.

The application of edge diffraction techniques has been successfully extended under this program. The importance of shadow boundary phenomena has been determined in the analyses of impedance and patterns of parallel-plate waveguides. In the edge diffraction method the general behavior of a diffraction from an edge is that of a source localized at the edge. However, near shadow boundaries the characteristics are different in two ways - the edge diffraction source appears more closely related to the original source and the amplitude varies rapidly near the shadow boundary. Techniques for treating these characteristics are being investigated. A new type of diffraction has been introduced for treating the non-uniform aspect of illuminating waves. It is the wedge diffraction by a two-dimensional dipole source with its null aligned with the edge of the wedge. Since shadow boundary effects are important to the application of edge diffraction techniques, it is proposed to continue this study.

The extension of edge diffraction techniques to three-dimensional problems needs to be studied. The problem of diffraction by an isolated rectangular corner could be applied to the rectangular waveguide aperture. The accomplishment of this result would allow the application of all existing edge diffraction techniques to the rectangular waveguide and provide insight for other three-dimensional problems. It is proposed to determine the diffraction from a rectangular corner by using the information available about edge diffraction from two-dimensional theory and the known characteristics of three-dimensional diffraction from conventional diffraction theory.